Assessing stratospheric aerosols contamination due to space activities

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Abstract

The life cycle of a spacecraft starts and ends in the atmosphere: it interacts with the atmosphere right after the launch and during the atmospheric reentry when it usually mostly ablates. Both phases induce emissions of gases and solid particles, providing a source of these components in the middle atmosphere. Little is known about the exact nature, composition and effects of these emissions on the atmosphere and climate, but their impact is expected to rise as more and more orbiting satellites are launched. Ever since the years 2000, the number of space rockets launched per year has increased by a factor 3 globally. At the same time, the number of satellites launched in orbit around the Earth per year has been multiplied by about 30. One may wonder whether changes in the anthropogenic material injected in the terrestrial stratosphere can be detected and what its influence may be.

In order to study the cosmic dust particles arriving on Earth, the NASA Johnson Space Center (JSC) has been systematically collecting solid dust particles from the Earth's stratosphere by aircraft equipped with dedicated particle collectors since 1981. So far, 25 catalogs have been published, covering campaigns of collection from 1981 to 2020, with a total of 5071 solid particles that have been preliminary characterized and curated. In this work, we use the preliminary classification of the dust particles. Based on SEM images and X-ray EDS composition the collected dust is separated into four groups: C (Cosmic), TCN (Terrestrial Contaminant Natural), TCA (Terrestrial Contaminant Artificial) and AOS (Aluminum Oxide Sphere). The AOS being mostly generated by solid rocket propellant, they also belong to the TCA class. Our analysis of the data published indicates that from 1980 to 2009 the cosmic dust particles typically represent on average 40% of the collection with TCA and TCN corresponding to about 30% each. In the recent years, the TCA fraction has doubled to about 60% of the collection (2010-2020). This increase in anthropogenic particles is likely due to the overall human space activity and its recent increase. We will present the properties of the solid stratospheric dust particles collected and their evolution with time.

Future work will be dedicated to better classify the natural and anthropogenic particles collected and described in the existing databases. We will use numerical modelling to produce quantitative estimates of the injected mass, the lifetime of particles in the middle atmosphere (stratosphere) and the relative abundance of the anthropogenic particles with respect to the stratospheric background particle population.